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EXECUTIVE SUMMARY

The Building Block Instream Flow Assessment methodology was developed as a quick estimate of the IFRs on request from DWAF. The method has never been tested, and it is therefore important to monitor IFR releases to see whether the Desired Future State (DFS) of the river is being achieved. This process is referred to as IFR monitoring which is basically an iterative process whereby key indices measured during surveys subsequent to development (construction & operation phase) are repeatedly compared with baseline values and subsequent follow-up values (collected prior to development eg design phase). IFR monitoring is therefore recommended and is seen as part of the whole IFR process.

The IFR monitoring has never been undertaken and as funds will not be available for the development of methods and indices in general, these will have to be developed through application of monitoring on a specific river, possibly the Sabie River which will be the first river where the IFR monitoring will be applied.

A monitoring protocol which would describe the monitoring activities in the Sabie and Sand Rivers was therefore required. This report represents the findings of a group of IFR specialists involved in the Sabie IFR study during a two day workshop (29 and 30 July 1997) to establish the Sabie IFR monitoring protocol.

The purpose of the workshop was to provide the Department of Water Affairs and Forestry (DWAF) with the scope and programme required for the baseline survey and long term monitoring and the associated manpower costs for the actions that

- **are not being undertaken as part of other monitoring actions;**
- **and that cannot be supplied by other government agencies.**

The IFR monitoring study area was identified as similar to the IFR study area i.e. the Marite and Sabie River downstream of Injaka Dam to the Mozambique border and the Mutlumuvi river from the transfer point downstream to the Sand River, including the Sand River to the confluence with the Sabie River.

The monitoring was devided in two phases, the base line surveys (August 1997 to September 1998) and the long term monitoring starting immediately afterwards and estimated for a period of 10 years.

The results of the monitoring protocol for the base line survey and the long term monitoring are summarised in the tables below.

Base Line Survey

Column 3 : Total time in days for the specific resource
Column 4 : Time costs in rand (based on estimated hourly tariffs - 1997 values)
Column 5 : Disbursements to the value of 20 % are added to column 4.
Column 6 : Estimate of the costs (time) with 20% disbursements that could be spent prior to the end of the financial year (31 March 1998).
Column 7 : Estimate of the additional costs during the 98/99 financial year.
Please note that the hydrology estimate INCLUDES aspects of the study that could be covered by other DWAF and KNPRRP studies.

MONITORING COMPONENT	RESOURCES	TIME DAYS	COST	+ DISB	PRIOR TO 3/98	3/98 - 9/98
HYDROLOGY	Technician	30	28 800	47 808	12 504	35 304
	Specialist	6	11 040			
HYDRAULICS	Specialist	8	12 800	15 360	1 920	13 440
GEOMORPH	Technician	10	12 000	102 720	28 704	74 016
	Specialist	40	73 600			
RIPARIAN VEGETATION	Technician	7	5 600	49 848	14 592	35 256
	Specialist	16	29 440 + 6 500			
FISH	Specialist	34	16 080	19 296	480	18 816
AQUATIC INVERTS	Technician	90	86 400	218 880	20 400	198 480
	Specialist	48	96 000			
WATER QUALITY	Technician	25	24 000	108 000	91 680	16 320
	Specialist	33	66 000			
CO-ORDINATION, DATA MANAGEMENT		80	135 200	162 240	48 384	113 856
TOTAL			603 460	724 152	218 664	505 488

Long term monitoring

Note that the cost give is for 10 years.

MONITORING COMPONENT	RESOURCES	TIME DAYS	COST	+ DISB
HYDROLOGY	Technician	62,5	60 000	162 528
	Specialist	41	75 440	
HYDRAULICS	Specialist	96	121 600	145 920
GEOMORPH	Technician	18	17 280	226 080
	Specialist	93	171 120	
RIPARIAN VEGETATION	Technician	35	35 000	186 840
	Specialist	55	101 200 + 19 500	
FISH	Specialist	140	140 800	168 960
AQUATIC INVERTS	Technician	130	124 800	365 760
	Specialist	90	180 000	
WATER QUALITY	Technician	100	96 000	283 200
	Specialist	70	140 000	
CO-ORDINATION, DATA MANAGEMENT		200	320 000	384 000
TOTAL			1 602 740	1 923 288

CONTENTS

1. INTRODUCTION & BACKGROUND

1.1 INSTREAM FLOW REQUIREMENT (IFR) MONITORING

The Building Block Instream Flow Assessment methodology was developed as a quick estimate of the IFRs on request from DWAF. The method has never been tested, and it is therefore important to monitor IFR releases to see whether the Desired Future State (DFS) of the river is being achieved. This process is referred to as IFR monitoring which is basically an iterative process whereby key indices measured during surveys subsequent to development (construction & operation phase) are repeatedly compared with baseline values and subsequent follow-up values (collected prior to development eg design phase). IFR monitoring is therefore recommended and is seen as part of the whole IFR process.

The detailed reasons for undertaking IFR monitoring are

- **from an ecological viewpoint:**
  - **To check whether IFR releases are reaching the IFR sites;**
  - **To measure whether the DFS is being achieved;**
  - **If the DFS is not being achieved to recommend operational changes;**
  - **To further develop the Building Block Methodology (BBM) based on the monitoring results.**
- **from a socio-economic viewpoint:**
  - **To check whether water is being used cost-effectively.**

The IFR monitoring fits in the different phases of project development and the Building Block Method (BBM) as follows:

Reconnaissance phase of development:

- **Habitat integrity**
- **Bulk Water Estimate**

Pre-feasibility phase of development:

- **IFR planning meeting**
- **IFR site selection**
- **Studies for IFR determination**
- **IFR workshop**

Feasibility phase of development:

- **IFR refinement**
- **IFR hydrological scenario meetings**
- **Public participation process to determine the final DFS**
- **Design of a monitoring protocol**

Design phase of development

- **Base line collection for monitoring**

Construction and operation

- **Longterm monitoring**
- **Continuous adjustment of IFR based on monitoring results**

A monitoring protocol (see last bullet under feasibility phase above) has been designed for the Luvuvhu, Mooi, Mvoti, Berg and Letaba Rivers. Monitoring protocols on the Bivane and Tugela Rivers are still outstanding. No IFR monitoring protocol has yet been put into practice as the monitoring activities are project driven and the dams which will release the IFRs still have to be completed (Injaka Dam) and initiated. (see last 3 bullets above)

Some of the perceived problems with IFR monitoring are:

- **The monitoring results should identify changes in the base line cause specifically by changes in flow.**
- **The cause of flow related changes to link it to IFR releases should be identified.**
- **The available monitoring indices are possibly not suitable for IFR monitoring.**
- **The IFR monitoring has never been undertaken and as funds will not be available for the development of methods and indices in general, these will have to be developed through application of monitoring on a specific river, possibly the Sabie River which will be the first river where the IFR monitoring will be applied.**
- **Available expertise is limited.**
- **Monitoring needs to be immediately responsive and should identify changes quickly.**
- **The co-ordination and management of such a programme over the long-term could be problematic.**
- **The liaison and co-ordination with all the other monitoring programmes could be problematic.**

1.2 SABIE IFR STUDY

The Sabie IFR study was initiated during the Design and Construction phase of the development of Injaka Dam during 1995. The IFR workshop took place in August 1996 where the first estimate of IFR results were tabled. The following consecutive steps in the IFR process are being undertaken subsequent to the IFR workshop:

- **The refinement of the IFR results.**

  The most important and immediate uncertainties that could influence the IFR results significantly were identified at the IFR workshop. These are being undertaken at present and are the following:

  * **The hydraulic calibration of all the sites, especially for low flows at the bedrock anastomosing IFR sites.**
  * **The determination of the possible consequences of changing the Sand River to a more perennial system.**
  * **A social utilisation study on the Mutlumuvi River similar to that which was done on the Marite River for the IFR workshop.**

  The above studies would recommend IFR changes if any.

- **A hydrological study for Injaka Dam is being initiated by DWAF which will include the following:**
  * **Determine the amount of water available:**
  * **Determine the operating rules of the dam:**
  * **Determine the systems and structures required to operate the system.**

- **The initiation of IFR monitoring for the Sabie River which consists of three interrelated actions:**
  * **The defining of a monitoring protocol specific to the Sabie System.**
  * **A base line survey to collect sufficient and relevant information during the pre-construction period for use during the post construction monitoring.**
  * **Post construction monitoring.**

This report represents the findings of a group of IFR specialists involved in the Sabie IFR study during a two day workshop (29 and 30 July 1997) to establish the Sabie IFR monitoring protocol.

1.3 OTHER MONITORING INITIATIVES IN THE SABIE CATCHMENT

Various monitoring activities are being centred around the Sabie River due to its regional and national importance and the wealth of information available on the Sabie River. These actions are:

- **NATIONAL AQUATIC ECOSYSTEM BIOMONITORING PROGRAMME (NAEBP)**
  The NAEBP has selected the Sabie River as one of the rivers to test the NAEBP on and monitoring is being initiated in the Kruger National Park (KNP) during August 1997.
- **MPUMALANGA PROVINCIAL INITIATIVE**
  Monitoring forms part of the new strategic policy of the Mpumalanga Parks Board (MBP) and the Sabie River and tributaries have been identified as rivers on which monitoring will take place.
- **KRUGER NATIONAL PARK RIVERS RESEARCH PROGRAMME (KNPRRP)**
  One of the sub programmes of the third phase of the KNPRRP is monitoring and the Sabie River will also form part of activities undertaken as part of the programme.
- **KNP MONITORING**
  The KNP has a detailed specified monitoring programme on all their rivers.

The monitoring initiatives presently being developed such as the National Aquatic Ecosystem Biomonitoring Programme (NAEBP) will not be suitable for IFR monitoring. IFR monitoring is more intensive and specific to flow related changes. Some of the components of the NAEBP programme might however be suitable and these components were established during this workshop.

2. SABIE IFR MONITORING WORKSHOP

2.1 PURPOSE OF SABIE IFR MONITORING WORKSHOP

The purpose of the workshop is summarised as follows:

To provide the Department of Water Affairs and Forestry (DWAF) with the scope and programme required for the baseline survey and long term monitoring and the associated manpower costs for the actions that

- **are not being undertaken as part of other monitoring actions;**
- **and that cannot be supplied by other government agencies.**

In more detail the workshop followed a consecutive question and answer approach based on the following steps:

- **Determine the baseline information required for the IFR monitoring.**
- **Determine how the baseline information and IFR monitoring will be undertaken, i.e. the programme and scope.**
- **Determine which of the actions that form part of the above are covered by over monitoring actions.**
- **For actions not covered by other monitoring actions, determine which can be undertaken by government departments and Sabie-Sand private game reserves.**
- **Determine the manpower cost for the actions not covered elsewhere and which cannot be undertaken by government departments.**
- **List specialists who are capable of undertaking these different tasks.**
- **Determine how such a programme can be managed.**

The purpose of this programme will therefore not be to duplicate any other actions in process but to establish IFR-specific monitoring.

2.2 PARTICIPANTS

See Appendix 1 attached

2.3 WORKSHOP PROGRAMME & APPROACH

The workshop programme is attached as Appendix 2. The approach during the workshop was based on answering the questions posed in 2.1 in groups and giving feedback during

plenary sessions. The groups documented their findings in the format of Table 1 and were responsible for their own scribing. The groups and the disciplines they represented were the following:

- **Hydrology and Hydraulics:**
  Andrew Birkhead (Centre for Water for the Environment (CWE))
  Bill Rowlston (DWAF) **Angelina Jordanova (DWAF)**
  Denis Hughes (Institute for Water Research (IWR))

- **Fluvial geomorphology and geohydrology**
  Freek Venter (KNP) **Evan Dollar (IWR)**
  Kelvin Legge (DWAF)

- **Riparian vegetation**
  Nigel Kemper (IWR Environmental) **James MacKenzie (CWE)**

- **Fish**
  Neels Kleynhans (DWAF) **Andrew Deacon (KNP)**
  Johan Engelbrecht (MPB)

- **Aquatic invertebrates and Water quality**
  Jay O'Keeffe (IWR) **Tally Palmer (IWR)**
  Dirk Roux (CSIR)

- **Co-ordination**
  Delana Louw (IWR Environmental)

Each of the groups were supplied with the following:

- **A1 copies of Table 1.**
- **A summarised version of the Desired Future State and IFR objectives for each IFR site as documented at the IFR workshop (Appendix 3).**
- **A diagrammatic map depicting the IFR study area and IFR sites. (Fig 1)**

Fixed point photography of the IFR sites at different flows were also available.

TABLE 1 : IFR MONITORING TABLE

BASELINE STUDY / 10 YEAR MONITORING : RIVER _____: SPECIALITY : _____

.OBJECTIVES	.TPCs	ACTIONS.
.	.	.NR: NR:

Act	IFRM site	Monitoring Frequency	Resources (eg specialist, technician)	Covered / Budgeted elsewhere	Rates	Time	Cost
Nr	1						
	2						
	3						
	4						
	5						
Nr	1						
	2						
	3						
	4						
	5						

3. IFR MONITORING STUDY AREA & MONITORING SITES

The IFR monitoring study area was identified as similar to the IFR study area i.e. the Marite and Sabie River downstream of Injaka Dam to the Mozambique border and the Mutlumuvi river from the transfer point downstream to the Sand River, including the Sand River to the confluence with the Sabie River.

The IFR monitoring intensity will be similar for all the sites although the actions undertaken at the sites will differ according to their specific characteristics. See Fig 1 below.

Each group investigated the IFR sites at which monitoring activities will be required. The results of this were grouped and it was found that only the fish group required any work at site 2, although they will work in the near vicinity and not at the site itself. It was therefore decided that it would not be cost-effective to include IFR 2 as a monitoring site and it was deleted from further investigations.

4. BASELINE SURVEY

Each of the groups documented their results of the various group discussions. The various discussions are summarised under the heading of the discipline below with reference to any discussions during plenary below the tables.

The compiler of the report was also requested to make an estimate of the costs of the base-line survey that could be spent prior to the end of March 1998. The estimated costs are given in the last row of each of the tables.

The base-line monitoring period will be for one year, starting August 1997 to September 1998. The September 1998 limit is caused by the construction activities that will during that period cause significant changes in the flow regime, more than that which is presently the case.

Please note the following:

- **Possible costs refer to the costing of studies where uncertainty exists whether they will form part of other studies, and whether DWAF will undertake the work.**
- **TPC = Threshold of Probably Concern, refers to the rate of change, duration of exceedance and value.**
- **NR (Column 1) = refers to the numbered action in the row above.**
- **IFRMS = IFR monitoring site (site number equal the IFR site numbers)**
- **Freq = how often during one year (base-line)**
- **Resources = the resources such as specialists, technicians etc required for the monitoring.**
- **Elsewhere = is the work undertaken as part of another monitoring initiatives or being undertaken by government departments.**
- **Rate = estimated price per day in rands**
- **Time (day) = refers to 8 hour days**
- **Cost (R) = rate x time**
- **d/s = downstream**
- **If uncertainty is indicated in the Elsewhere Column, the cost are still given for some of the components.**
- **DSS = Decision support system**
- **All costs below excludes disbursements. Disbursements were not quantified as they will differ significantly pending on the locality of the consultant undertaking the work. A figure of 20% of the time costs have been added below for disbursements.**
- **n/a = not applicable**

4.1 HYDROLOGY

OBJECTIVES:

Determine the spatial variability of flows along the length of the river by the quantifying abstractions.

TPCs

Some expression of the comparison between the observed flow regime and that specified in the IFR exercise (eg. percentage time at drought flows).

NR ACTIONS

1. **Survey water abstractions (direct abstractions for irrigation, domestic etc). Review data on riparian vegetation use. Quantify seasonal distribution.**
2. **2 co-ordination meetings with the rest of the monitoring team.**
3. **DSS design meeting.**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1	Sabie: X3H006 (d/s) Marite: X3H011 (d/s) Sand : Whole	1	3 Technicians	Maybe by KNPRRP Schulze project if accepted.	960	30	28 800
			Hydrologist	Maybe by DWAF hydrology project for operation of Injaka Dam	1 840	3	5 520
TOTAL OF POSSIBLE COST							34 320
2.	n/a	2	Hydrologist	No	1 840	2	3 680
3.	n/a	1	Hydrologist	No	1 840	1	1 840
TOTAL OF DEFINITE COSTS							5 520
TOTAL							39 840

Possible costs + 20 % disbursement:	41 184
Definite costs + 20 % disbursement:	6 624
Total costs + 20 % disbursement:	47 808

Cost prior to March 1998:

Possible (25% of action 1) : R8 580

Definite (1 meeting of action 2) : R1 840

4.2 HYDRAULICS

OBJECTIVES:
Establish hydraulic characteristics of all sites to be used in other monitoring activities.

TPCs
'Significant' changes in hydraulic characteristics indicative of morphological adjustments responding to changes in the hydrological and sediment regime.

NR ACTIONS

1. **Collect additional hydraulic data at the complex sites for 3 flows to increase the confidence in existing data.**
2. **Resurvey the sites that have been surveyed prior to large floods to determine cross-sectional changes.**
3. **Determine cross-sectional changes, establish new rating curves where sites have changed and report.**
4. **2 co-ordination meetings with the rest of the monitoring team.**
5. **DSS design meeting**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1	1,3,5,6,7,8	3	Technicians	Undertaken as part of the IFR refinement study	-	-	-
			Hydraulician		-	-	-
2	1,3,4,5,6,7,8 (possibly no change at 6 and 7)	1	Survey team	DWAF to be approached			
3	"	1	Hydraulician	No	1 600	5	8 000
4.	n/a	2	Hydraulician	No	1 600	2	3 200
5.	n/a	1	Hydraulician	No	1 600	1	1 600
TOTAL							12 800
Total costs + 20 % disbursement:							15 360

Cost prior to March 1998:
1 meeting of action 4 : R1 600

4.3 GEOMORPHOLOGY AND GEOHYDROLOGY

OBJECTIVES:

- **To confirm the geomorphological assumptions made in determining the IFR.**
- **To ensure that the geomorphological equilibrium of the Sabie Sand is maintained.**

TPCs

- **A large scale directional change of morphological units and water surface area.**
- **Significant (± 20%) changes in channel geometry.**
- **Significant (± 20%) changes in channel bed form.**
- **Significant (± 20%) changes in bed material load.**

NR ACTIONS

Active Channel:

1. **Fixed cross-sectional surveys to establish channel geometry and bank stability.**
2. **Morphological mapping.**
3. **Bed material sampling.**
4. **Data analysis and interpretations.**
5. **Fixed point photos**

Macro Channel :

6. **Air photo mapping**

General

7. **2 co-ordination meetings with the rest of the monitoring team.**
8. **DSS design meeting**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1	1,3,4,5,6,8		Survey team	Covered by hydraulics	-	-	-
2	"	2	Specialist	No	1 840	12	22 080
3	"	2	Specialist	No	1 840	12	22 080
			Technician		1000	12	12 000
4	n/a	1	Specialist	no	1 840	10	18 400
5	1,2,4,5,6,8	2	-	Covered by hydraulics	-	-	-
6	"	1	Specialist	Photography covered by riparian vegetation	1 840	3	5 520
7	n/a	2	Specialist	no	1 840	2	3 680
8.	n/a	1	Specialist	no	1 840	1	1 840
TOTAL							85 600
Total costs + 20 % disbursement:							102 720

Cost prior to March 1998:
Task 2 and 1 meeting of task 7 : R23 920

The movement of sediment from the Sand to the Sabie was seen as an important issue. It was however seamed as too extensive to be part of the monitoring programme, and should form part of a research programme. Andrew Birkhead is doing part of this work through the present IFR refinement study.

It was also discussed whether a site right downstream of the dam wall is required to monitor the effects of spillage and releases on the channel. Limited information is available on these effects. It was however felt that this does not form part of the IFR monitoring programme and should be referred to the Environmental Task Group for review as a separate study.

4.4 RIPARIAN VEGETATION

OBJECTIVES:

- **To maintain, at all sites, a viable population structure of site specific key species.**
- **At highly disturbed sites, where current ecological integrity is low, encourage, through flow manipulations, the rehabilitation of the riparian vegetation, in order to achieve the maintenance of the populations of the natural site specific key species.**
- **To develop and implement an early warning system to identify and quantify the extent of invasion of the riparian zone by terrestrial, exotic and aquatic macrophyte species.**
- **To maintain vegetation dynamics, within the riparian zone at each site, in accordance with the natural geomorphological patch dynamics.**
- **To iteratively refine the TPCs.**

ASSUMPTIONS

- **Populations of site specific key species at a site are persistent and are not the result of stochastic flow events in the past.**
- **Changes in the population structure of species present are indicative of changes in the flow regime only.**
- **The negative impacts of local utilisation of riparian species will be minimised by the development and implementation of a catchment management plan.**

TPCs

- **A presence of exotic and terrestrial species on active geomorphological features, and a 10% increase of exotic and terrestrial species on seasonal geomorphological features.**
- **The consistent increase (in excess of 10 percent between follow-up monitoring surveys) in aerial extent of *Phragmites*.**
- **The absence of germination and establishment (recruitment) of *Ficus sycomorus* after large flood events or at least once every 10 years in alluvial channel types.**
- **The significant mortality (10%) of middle aged and mature individuals of key species at sites.**
- **Absence of germination and establishment (recruitment) of key species at least once every 10 years.**
- **The absence of a reverse J-shaped population size class curve for *Breonadia salicina* in bedrock anastomosing channel types.**

NR ACTIONS

1. **Locate permanent monitoring sites, determine key species, define size classes and lay out quads measuring a 100m x the width of the macro channel floor.**
2. **Count individuals per size class / key species and determine presence/absence of terrestrial/exotic spp in quadrants and determine densities.**
3. **Construct population curves.**
4. **Analyse aerial photographs for aerial extent of *Phragmites* spp.**
5. **Compilation of monitoring guidelines manual.**
6. **Photo-point monitoring.**
7. **Reporting.**
8. **Taking of aerial photography.**
9. **2 co-ordination meetings with the rest of the monitoring team.**
10. **DSS design meeting.**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1	1,3,4,5,6,7	1	Technician	No	800	3	2 400
			Specialist		1 840	3	5 520
2	"	1	Technician	No	800	3	2 400
3	"	1	Specialist	No	1 840	4	7 360
4	"	1	Technician	No	800	1	800
5	"	1	Specialist	No	1 840	4	7 360
6	"	1	Technician	Covered under hydraulics - analysis under 7	-	-	-
7	n/a	1	Specialist	No	1 840	1	1 840
8.	1,3,4,5,6,7	1	Specialist	No	1 840	1	1 840
9	n/a	2	Specialist	No	1 840	2	3 680
10	n/a	1	Specialist	No	1 840	1	1 840
TOTAL							35 040
Aerial flight							6 500
GRAND TOTAL							41 540
Total costs + 20 % disbursement:							49 848

Cost prior to March 1998:

Action 1, 2, 3 and 1 meeting of action 9 : R12 160

Mpumalanga Parks Board might be able to provide the technician support for the riparian vegetation, but that will have to be confirmed. Therefore, the budget reflects the total cost, including the technician cost.

The issue of monitoring of exotic aquatic macrophytes was raised. The change in flows could be instrumental in such an increase and it was suggested

that the possible increase in the KNP be monitored as part of the crocodile and hippo count in the KNP.

4.5 FISH

OBJECTIVES:

Main objective : Maintain fish communities in all reaches in Integrity Class B.
Sub objective :

- **Determine species richness**
- **Determine community structure**
- **Determine relative abundances of species**
- **Determine population structure of indicator species**
- **Determine population health**

TPCs

- **Indicator species absent in areas known to be present**
- **Increase in tolerant spp (n); decrease in intolerant spp (n)**
- **Changes in relative abundances : increase in tolerant spp (n); decrease in intolerant spp (n)**
- **Changes in the size and age structure composition within a healthy population.**
- **Increase in incidence of abnormalities and anomalies.**

NR ACTIONS

1. **Monitor 3 - 5 sites per segment (as described by Rowntree in the IFR starter document) to determine baseline conditions - one 97 winter survey as part of the NAEBP**
2. **And one specific for the IFR (winter 1998).**
3. **Determine the relative FCII for sites in the segments and for each segment on its own. Develop a fish habitat index (Baseline assessment).**
4. **2 co-ordination meetings with the rest of the monitoring team.**
5. **DSS design meeting**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1	All IFR sites + additional where accessible	1	NAEBP	NAEBP 1997 survey	-	-	-
2	"	1	KNP specialist	No - Consulting fee to support budget	1 360	4	5 440
			Survey team	Supplied by KNP	-	-	-
			MPB specialist	No - Consulting fee to support budget	1 360	4	5 440
			Survey team	Supplied by MPB	-	-	-
3	"	1	Specialist	Supplied by MPB - require S & T	200	10	2 000
			Specialist	Supplied by KNP - require S & T	200	10	2 000
4	n/a	2	Specialist	Supplied by MPB - require S & T	200	2	400
			Specialist	Supplied by KNP - require S & T	200	2	400
5	n/a	1	Specialist	Supplied by MPB - require S & T	200	1	200
			Specialist	Supplied by KNP - require S & T	200	1	200
TOTAL							16 080
Total costs + 20 % disbursement:							19 296

Cost prior to March 1998:
One meeting of task 4 : R 400

4.6 AQUATIC INVERTEBRATES

OBJECTIVES:

To set and calibrate TPCs as well as acute (damage) indicators.

Indicators will be the 10 taxa that disappeared during the drought (attached as appendix 4).

To determine which sites to use for long-term monitoring.

TPCs

Graph

To be set during baseline study.

NR	ACTIONS
1.	**Desk top study :** Desk top synthesis of the existing information on the invertebrates of the Sabie/Sand River system
	a) Link samples to IFR sites
	b) Calculate SASS scores and ASPTs from the samples.
	c) Set initial TPC's as listed in the objectives
	d) Assess information about indicator taxa and refine list of indicator taxa.
2.	River survey:
	a) SASS at all IFR sites
	Keep SASS samples to check for indicator taxa and during the first collection check that kick sampling is appropriate for indicator taxa (eg compared to box sampling).
	b) HAM at each IFR site - to aid with site selection for monitoring.
	c) Collect a baseline species list from all habitats.
3.	Lab analysis
4.	Interpretation and reporting
	a) Put baseline year in context of hydrological record and in terms of the water quality record.
	b) Finalise TPCs.
	c) Finalise sites
5.	2 co-ordination meetings with the rest of the monitoring team.
6.	DSS design meeting

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1.	1,3,4,5,6,7,8	1	Specialist	No	2000	15	30 000
			Assistant	No	960	30	28 800
2	"	4	Specialist	One survey covered by NAEPB except for checking of indicator taxa. Budget is for above + 3 surveys	2 000	15	30 000
			Assistant		960	20	19 200
3	n/a	1	Specialist	No	2 000	5	10 000
			Assistant		960	40	38 400
4	n/a	1	Specialist	No	2 000	10	20 000
5	n/a	2	Specialist	No	2 000	2	4 000
6	n/a	1	Specialist	No	2 000	1	2 000
TOTAL							182 400
Total costs + 20 % disbursement:							218 880

Cost prior to March 1998:

Some of task 1 : **R15 000**
One meeting of task 5 : **R 2 000**

4.7 WATER QUALITY

OBJECTIVES:

- **To refine and update the TPCs suggested for the KNP, using historical data and new guidelines**
- **To identify spatial gaps in the database.**
- **To develop simple indicators of water quality (for human use) e.g. smell, algae, colour.**

TPCs

To be refined and finalised during baseline study.

NR ACTIONS

1. **Desk top study investigation of water quality databases to update van Veelen (1991).**
2. **a) Refine TPCs already set for the KNP using results of 1 and new DWAF water quality guidelines.**
   b) Identify areas of catchment where data is lacking or insufficient.
   c) Identify simple indicators of water quality for human use (e.g. colour, smell, health problems).
3. **Institute the low frequency, high density sampling programme - first survey.**
4. **2 co-ordination meetings with the rest of the monitoring team.**
5. **DSS design meeting**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1.	n/a	1	Specialist	No	2 000	10	20 000
			Assistant	No	960	15	14 400
2	"	1	Specialist	No	2 000	20	40 000
3	40 sites	1	Assistant	Assume sample analysis at IWQS	960	10	9 600
4	n/a	2	Specialist	No	2 000	2	4 000
5	n/a	1	Specialist	No	2 000	1	2 000
TOTAL							90 000
Total costs + 20 % disbursements (includes chemicals):							108 000

Cost prior to March 1998:

Task 1, 2 and one meeting of task 4 R76 400

4.8 CO-ORDINATION AND DATA MANAGEMENT

OBJECTIVES:

Co-ordination

- **To co-ordinate all monitoring actions.**
- **To arrange the meetings and data to be available at meetings, and report on the meetings.**
- **To manage the monitoring subconsultants and administer the contract.**
- **To liaise with the client.**
- **To collate contributions to the final report.**

Data management

- **To set up a format for a central database through liaison with all the specialist and obtaining information regarding the format in which they will be preparing data.**

NR ACTIONS

1. **Co-ordination - include all actions as well as participation in meetings.**
2. **Set up a central data base.**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1	n/a	n/a	Specialist	No	1 600	50	80 000
2	n/a	n/a	Specialist	No	1 840	30	55 200
TOTAL							135 200
Total costs + 20 % disbursements:							162 240

Cost prior to March 1998:

40 320

5. 10 YEAR MONITORING

The long term monitoring is documented in the same way as for the base-line surveys, except that frequency now refers to the occurrence of events out of a period of 10 year. No escalation costs are included and the budget reflects 1997 costs.

5.1 HYDROLOGY

OBJECTIVES:
To determine the degree of concurrence between actual and IFR-specified flow regime.

NR ACTIONS

1. **Establish and calibrate a rated section on Marite close to IFR 1 (includes installation of continuous water level recorders). Require one cross-sectional survey and flow data collection for a full range of flows (approximately 15)**
2. **Modify the existing weir on the Mutlumuvi near IFR 6 OR, establish a rated section. (includes installation of continuous water level recorders). Require construction and/or one cross-sectional survey and data collection for a full range of flows.**
3. **Modify the existing low flow gauging weir near IFR 8 (manual, weekly readings will suffice).**
4. **Ongoing update of abstractions.**
5. **Hydrological modelling : ongoing update of calibration (making use of abstraction and release information to extrapolate/interpolate between gauging sites).**
6. **Preparation of hydrological monitoring manual and updating.**
7. **2 co-ordination meetings with the rest of the monitoring team per year.**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1	1	-	Survey team	Hydraulics with one extra day required	-	-	-
			Discharge gauging team	Ongoing gauging - 15 points : DWAF	-	-	-
2	6	-	As for above or construction team	Combined with above/ DWAF responsible for construction	-	-	-
3	8	1 repair Weekly gauging	Construction team Technicians	DWAF for construction Observations part of National gauging Network	-	-	-
4	X3H006,X3H011,Sand	5	Technician	No	960	62,5	60 000
5	n/a	after above=5	Specialist	No	1 840	15	27 600
6	n/a	3	Specialist	No	1 840	6	11 040
7	n/a	20	Specialist	No	1 840	20	36 800
TOTAL							135 440
Total costs + 20 % disbursement:							162 528

5.2 HYDRAULICS

OBJECTIVES:

Measure changes in morphological characteristics of channel cross-sections and associated changes in hydraulic characteristics.

NR ACTIONS

1. **Resurvey cross-sections (collect additional hydraulic data and photographs)**
2. **Collection of additional stage vs discharge data for recalibration. If significant changes in hydraulic control, then re-evaluate hydraulic relationships.**
3. **Preparation of hydraulic monitoring manual and updating.**
4. **2 co-ordination meetings with the rest of the monitoring team per year**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1	1,3,5,6,7,8	3 & after significant floods	Survey team	DWAF to be approached	-	-	-
			Hydraulician	No	1 600	6	9 600
2	1,3,4,5,6,7,8	20 (low and high flows)	Gauging team	DWAF to be approached			
			Hydraulician	No	1 600	50	80 000
3	n/a	10	Hydraulician	no	1 600	6	32 000
4.	n/a	20	Hydraulician	no	1 600	20	32 000
TOTAL							121 600
Total costs + 20 % disbursement:							145 920

In 6.1 and 6.2 it is assumed that DWAF will undertake cross-sectional surveys when required and all the flow gauging. If for any reason this is not the case, an additional R400 000 (10 years) must be budgeted for gauging alone.

5.3 GEOMORPHOLOGY AND GEOHYDROLOGY

OBJECTIVES:
See baseline

NR ACTIONS
Active Channel:
1. Fixed cross-sectional surveys to establish channel geometry and bank stability.
2. Morphological mapping.
3. Bed material sampling.
4. Data analysis and interpretations.
5. Fixed point photos.
Macro Channel :
6. Air photo mapping.
General
7. Preparation of geomorphology monitoring manual and updating.
8. 2 co-ordination meetings with the rest of the monitoring team per year.

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1	1,3,4,5,6,8		Survey team	Covered by hydraulics	-	-	-
2	"	10	Specialist	No	1 840	50	92 000
3	"	3	Technician	no	960	18	17 280
4	n/a	10	Specialist	no	1 840	10	18 400
5	1,2,4,5,6,8	2	-	Covered by hydraulics	-	-	-
6	"	1	Specialist	No	1 840	3	5 520
7	n/a	10	Specialist	No	1 840	10	18 400
8.	n/a	20	Specialist	no	1 840	20	36 800
TOTAL							188 400
Total costs + 20 % disbursement:							226 080

5.4 RIPARIAN VEGETATION

OBJECTIVES:
See baseline

NR ACTIONS

1. **Count individuals per size class for key spp in March/April, fixed photo point monitoring.**
2. **Construct curves/data analysis**
3. **Data interpretation**
4. **Assess aerial photo's**
5. **Assess aerial extent of *Phragmites* spp, exotics, terrestrial spp.**
6. **Update guidelines manual**
7. **Liaison with hydrologist / hydraulician for causal factors**
8. **Taking of aerial photography**
9. **2 co-ordination meetings with the rest of the monitoring team per year**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1	1,3,4,5,6,7	10	Technician	No	1 000	25	25 000
2	"	10	Specialist	No	1 840	5	9 200
3	"	10	Specialist	No	1 840	5	9 200
4	"	3	Technician	No	1 000	10	10 000
5	"	10	Specialist	No	1 840	5	9 200
6	"	10	Specialist	No	1 840	5	9 200
7	n/a	10	Specialist	No	1 840	5	9 200
8.	1,3,4,5,6,7	3	Specialist	No	1 840	10	18 400
9	n/a	20	Specialist	No	1 840	20	36 800
TOTAL							136 200
Aerial flight							19 500
GRAND TOTAL							155 700
Total costs + 20 % disbursement:							186 840

Mpumalanga Parks Board might be able to provide the technician support for the riparian vegetation, but that will have to be confirmed. Therefore, the budget reflects the total cost, including the technician cost.

5.5 FISH

OBJECTIVES:

Main objective : Maintain fish communities in all reaches in Integrity Class B.

Sub objective :

- **Maintain species richness for the Sabie/Sand Rivers.**
- **Maintain healthy community structure.**
- **Maintain relative abundances of species.**
- **Maintain healthy population structure of indicator species.**
- **Maintain fish health.**

NR ACTIONS

1. **Do FCII (with subcomponent analysis) in winter and compare results to baseline conditions defined.**
2. **Undertake ad hoc monitoring to focus on cause and effect relationships.**
3. **Reassess and refine TPCs annually**
4. **Preparation of fish monitoring manual and updating.**
5. **2 co-ordination meetings with the rest of the monitoring team per year**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1	IFR sites and others where necessary	10	KNP specialist	No - Consulting fee to support budget	1 360	40	54 400
			Survey team	Supplied by KNP	-	-	-
			MPB specialist	No - Consulting fee to support budget	1 360	40	54 400
			Survey team	Supplied by MPB	-	-	-
2	where necessary	?	Specialist & survey team	Supplied by KNP & MPB As this will only take place if required, a lump sum is budgeted for			20 000
3	n/a	10	Specialist : 2	Supplied by NPB & MPB - require S & T	200	20	4 000
4	n/a	10	Specialist : 1	Supplied by NPB & MPB	-	-	-
5	n/a	20	Specialist : 2	Supplied by NPB & MPB - require S & T	200	40	8 000
TOTAL							140 800
Total costs + 20 % disbursement:							168 960

5.6 AQUATIC INVERTEBRATES

OBJECTIVES:

To use data to measure conditions and trends at a site specific level, to indicate TPCs using

- **SASS (Total score, ASPT and HAM)**
- **Indicator taxa (presence, absence and abundance)**

NR ACTIONS

1. **Sample once a year at low flows for indicator spp.**
2. **Lab analysis of samples collected.**
3. **Sample once in 5 years for a full spp list and habitat every 5 years with appropriate lab analysis of samples collected in 3.**
4. **Interpret trend and write reports and preparation of monitoring manual and updating.**
5. **2 co-ordination meetings with the rest of the monitoring team per year.**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1.	1,3,4,5,6,7,8	10	Specialist	NAEBP	-	-	-
			Assistant	NAEBP	-	-	-
2	"	10	Specialist	No	2 000	10	20 000
			Assistant		960	50	48 000
3	"	2	Specialist	No	2 000	10	20 000
			Assistant		960	80	76 800
4	n/a	10	Specialist	No	2 000	50	100 000
5	n/a	20	Specialist	No	2 000	20	40 000
TOTAL							304 800
Total costs + 20 % disbursement:							365 760

6.7 WATER QUALITY

OBJECTIVES:

- **To use existing and planned SASS sampling and water chemistry data to measure compliance with TPCs.**
- **To institute a low frequency sampling programme of a few key variables (e.g. nutrients, salinity, oxygen, temperature, turbidity, pH, smell and algae etc at a large number of easily accessible sites through the catchment.**

NR ACTIONS

1. **To make use of existing monitoring programmes to match data to TPCs. Institute the low frequency, high density sampling programme (as described in objectives).**
2. **Annual report and data, analysis, preparation of monitoring manual and updating.**
3. **2 co-ordination meetings with the rest of the monitoring team per year.**

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1.	40 sites	10	Assistant	No	960	100	96 000
2	n/a	10	Specialist	No	2 000	50	100 000
3	n/a	20	Specialist	No	2 000	20	40 000
TOTAL							236 000
Total costs + 20 % disbursement:							283 200

5.8 CO-ORDINATION AND DATA MANAGEMENT

OBJECTIVES:

Co-ordination

- **To co-ordinate all monitoring actions.**
- **To arrange the meetings and data to be available at meetings, and report on the meetings.**
- **To manage the monitoring subconsultants and administer the contract.**
- **To liaise with the client.**
- **To collate contributions to the annual report.**
- **To be the liaison between the monitoring team and the technical committee.**
- **To be the contact during crisis times when monitoring indicate that TPCs are being exceeded.**
- **To determine required action when the above happens and arrange whatever is required.**
- **To ensure that the yearly update of the monitoring manuals and databases is being undertaken.**

Data management

- **To manage the central data base and ensure that the data is being updated regularly.**

NR ACTIONS

1. Co-ordination - include all actions as well as participation in meetings.
2. Yearly update of central data base.

NR	IFRMS	FREQ	RESOURCES	ELSEWHERE	RATE	TIME	COST
1	n/a	n/a	Specialist	No	1 600	200	320 000
2	n/a	n/a	Specialist	DWAF	-	-	-
TOTAL							320 000
Total costs + 20 % disbursements:							384 000

6. CAPABLE SPECIALISTS

Please note that the lists stipulated below are not necessarily complete and do not exclude other consultants. It should just be seen as a guide to the client indicating some of the expertise available in the different specialities.

6.1 HYDROLOGY

Dennis Hughes (IWR)
Roland Schulze & team
Andre Görgens (Ninham Shand)
Vladimir Smakhtin (IWR)
Phillip Odendaal (DWAF)

Note only 2 models exist to deal with daily flows : Rhodes IWR model and ACRU model.

6.2 HYDRAULICS

Andrew Birkhead (CWE)
Angelina Jordanova (DWAF)
Bill Rowlston (DWAF)
Chris James (CWE)
Rudoph Ras
Jeremy Cooke

6.3 FLUVIAL GEOMORPHOLOGY

Kate Rowntree (IWR)
George Heritage (University of Newcastle)
Evan Doller (IWR)
Roy Wadeson

6.4 RIPARIAN VEGETATION

Nigel Kemper (IWR)
Alan van Coller (CWE)
G Marneweck
James MacKenzie (CWE)
Kevin Rogers (CWE)
Anton Lindströhm

6.5 FISH

Neels Kleynhans (DWAF)
Francios Roux (MPB)
Johan Raal (Ecosun)
Dez Weeks (IWR)
Johan Engelbrecht (MPB)
Andrew Deacon (KNP)
Anton Bok (JLB Smith)

6.6 AQUATIC INVERTEBRATES

Mark Chutter (Afridev)
Rob Palmer (Afridev)
Ferdi de Moor (Albany Museum)
Helen Barber-James (Albany Museum)
Helen Dallas (Southern Waters)
Cate Brown (Southern Waters)
Rebecca Tharme (Southern Waters)
Jackie King (Southern Waters)
Jay O'Keeffe (IWR)
Tally Palmer (IWR)
Keker Soscujwa (IWR)
Many Uys (IWR)
Lil Haigh (IWR)
Peter Macmillan (CSIR)
Colleen Todd (CSIR)
Brian Fowles (CSIR)

6.7 WATER QUALITY

Jenny Day (Southern Waters)
Helen Dallas (Southern Waters)
Rob Palmer (Afridev)
Tally Palmer (IWR)
Patsy Goetsch (IWR)
Jay O'Keeffe (IWR)
Pete Ashton (CSIR)
Nico Rossouw (CSIR)
Martin van Veelen (BKS)
Gavin Quibell (Ninham Shand)
Guy Pegram (Ninham Shand)

6.8 CO-ORDINATION

The criteria established for the person or consultancy that can undertake the co-ordination was the following:

- **Understand and experienced in IFRs**
- **Backing and infrastructure to manage a large consulting contract**
- **Aquatic science background.**

Afridev
IWR (IWR Environmental)
Southern Waters
CSIR
Institute for Natural Resources

7. THE WAY FORWARD

7.1 TIMING AND ACTIONS REQUIRED TO APPOINT CONSULTANTS FOR BASE LINE MONITORING

Construction of Injaka Dam is already taking place and the baseline survey should have been undertaked prior to the initiation of construction. More severe changes in the present river conditions are expected after September 1998 when the river will be routed through an opening in the partly constructed dam wall. It is therefore vital to initiate the baseline survey immediately and complete it prior to September 1998.

Initiation of the study is required before February 1998 so that the wet season surveys can take place in the available time period. The dry season surveys were required in August 1997, but these surveys are being undertaken as part of the NAEBP monitoring surveys during Aug 1997. Some of the aquatic invertebrates sampled during this survey need to be kept for further analysis during this survey and IWQS will be informed regarding this by Mr Dirk Roux.

The following realistic programme of events to enable appointment before February 1998 was supplied by Mr Kelvin Legge. It was stated however that this schedule is only relevant if no unforseen problems occur.

- **Mid August 1997 :** **Draft IFR monitoring report available**
- **End August 1997 :** **Final report available**
- **September 1997 :** **Apply to DWAF management for permission to approach consultants.**
- **September 1997 :** **Request proposals from consultants.**
- **October 1997 :** **Obtain proposals and permission to appoint consultants**
- **November 1998 :** **Appoint consultants.**

If the value of the contract is less than 1,5 million rand, 3 consultants have to be considered, but it is not required to obtain 3 proposals.

7.2 TIMING AND ACTIONS REQUIRED TO APPOINT CONSULTANTS FOR LONG TERM MONITORING

The appointment of consultants for the long term monitoring will be a separate exercise and will only be required after September 1998. It was noted that monitoring needs to be initiated immediately after the baseline surveys, even though the dam might not be in operation. This is required to monitor construction impacts, the impacts of a possible artificial drought situation (when the dam is being filled) and to ensure that no unforseen events occur between baseline surveys and the monitoring which would change the base line prior to the monitoring.

The long term monitoring of a river has never been undertaken except for the Great Brak River

Estuary and the Pongola Flood Plain. The concept of the Great Brak River Estuary was that the users of the dam should pay for the monitoring. Mr Bill Rowlston from the DWAF Strategic Planning Division will inquire about the principles of funding the long term monitoring and methods to do this (such as, for instance, funding from water tariffs).

7.3 LIAISON WITH DWAF SURVEY, HYDROLOGY, CONSTRUCTION AND THE REGION.

The relevant directorates of DWAF not represented at the workshop need to be informed of the actions that will be required from them as part of monitoring. It must be established whether these services can be supplied and these actions should be included in the Directorates budgets where relevant. If these expected services cannot be supplied, adjustments will be required to the budgets in this document. Mr Rowlston will take this matter further.

7.4 STRATEGY OF ACTIONS DURING MONITORING.

The following issues were discussed in general.

- **The format of meetings : Liaison with the managers and operators of the dam should be through a technical committee with the specialists present. These meetings should be with the persons directly involved in making decisions regarding the operation of the dam. The results of these meetings and interpretations of monitoring results must also be presented to the I & APs and river forums such as the Sabie River Working Group. This must be done directly by a representative of the technical monitoring committee.**
- **DSS : A decision support system to describe the consecutive actions required when monitoring indicates problems must be formulated. Specialist should initiate the development of such a system during the collection of baseline data. A DSS will be designed during a one day meeting at the end of the base line survey.**
- **Range of possible causes leading to change : Part of the report on the baseline study should consists of a first level estimate of the likely changes that could take place. Some assessment of possible causes should be made. Advice on possible 'red flags' should be given.**

7.5 GENERAL

Mr Lorimar committed Sabie Sand to assist with non-technical support for any monitoring required at IFR 7.

8. SUMMARY

8.1 BASELINE SURVEY

The results of the monitoring protocol are summarised in the tables below.

Column 3 : Total time in days for the specific resource

Column 4 : Time costs in rand (based on estimated hourly tariffs - 1997 values)

Column 5 : Disbursements to the value of 20 % are added to column 4.

Column 6 : Estimate of the costs (time) with 20% disbursements that could be spent prior to the end of the financial year (31 March 1998).

Column 7 : Estimate of the additional costs during the 98/99 financial year.

Please note that the hydrology estimate INCLUDES aspects of the study that could be covered by other DWAF and KNPRRP studies.

MONITORING COMPONENT	RESOURCES	TIME DAYS	COST	+ DISB	PRIOR TO 3/98	3/98 - 9/98
HYDROLOGY	Technician	30	28 800	47 808	12 504	35 304
	Specialist	6	11 040			
HYDRAULICS	Specialist	8	12 800	15 360	1 920	13 440
GEOMORPH	Technician	10	12 000	102 720	28 704	74 016
	Specialist	40	73 600			
RIPARIAN VEGETATION	Technician	7	5 600	49 848	14 592	35 256
	Specialist	16	29 440 + 6 500			
FISH	Specialist	34	16 080	19 296	480	18 816
AQUATIC INVERTS	Technician	90	86 400	218 880	20 400	198 480
	Specialist	48	96 000			
WATER QUALITY	Technician	25	24 000	108 000	91 680	16 320
	Specialist	33	66 000			
CO-ORDINATION, DATA MANAGEMENT		80	135 200	162 240	48 384	113 856
TOTAL			603 460	724 152	218 664	505 488

8.2 10 YEAR MONITORING

The results of the monitoring protocol are summarised in the tables below.

Column 3 : Total time in days for the specific resource
Column 4 : Time costs in rand (based on estimated hourly tariffs - 1997 values)
Column 5 : Disbursements to the value of 20 % are added to column 4.
Note that the cost give is for 10 years.

MONITORING COMPONENT	RESOURCES	TIME DAYS	COST	+ DISB
HYDROLOGY	Technician	62,5	60 000	162 528
	Specialist	41	75 440	
HYDRAULICS	Specialist	96	121 600	145 920
GEOMORPH	Technician	18	17 280	226 080
	Specialist	93	171 120	
RIPARIAN VEGETATION	Technician	35	35 000	186 840
	Specialist	55	101 200 + 19 500	
FISH	Specialist	140	140 800	168 960
AQUATIC INVERTS	Technician	130	124 800	365 760
	Specialist	90	180 000	
WATER QUALITY	Technician	100	96 000	283 200
	Specialist	70	140 000	
CO-ORDINATION, DATA MANAGEMENT		200	320 000	384 000
TOTAL			1 602 740	1 923 288

APPENDIX 1

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APPENDIX 2

SABIE MONITORING PROTOCOL WORKSHOP

PROGRAMME

COBHART PLACE, 29 & 30 JULY 1997

Facilitator : Jay O'Keeffe

29 JULY 1997

09:30	**[30]**	**TEA**
10:00	**[5]**	**WELCOME (O'Keeffe)**
10:10	**[10]**	**BACKGROUND, PRESENT INITIATIVES PURPOSE OF THE WORKSHOP (Louw)**
10:20	**[10]**	**PLANNED APPROACH DURING THE WORKSHOP (O'Keeffe)**
10:30	**[30]**	**DETERMINATION OF STUDY AREA & PLANNED INTENSITY OF MONITORING IN DIFFERENT REACHES**
11:00	**[1H30]**	**DEFINE OBJECTIVES FOR MONITORING AND SET INITIAL TPC'S THROUGH GROUP DISCUSSIONS**
12:30	**[60]**	**LUNCH**
13:30	**[30]**	**REPORT BACK**
14:00	**[30]**	**DISCUSSION ON MONITORING SITES**
14:30	**[60]**	**DEFINE INFORMATION NEEDS TO MEET MONITORING OBJECTIVES (GROUP DISCUSSIONS)** **- identify indicator components** **- assess intensity of monitoring (no of sites, frequency of sampling)** **- need for indices** **- baseline studies**
15:30	**[30]**	**TEA**
16:00	**[60]**	**DESIGN A MONITORING PROGRAMME (GROUP DISCUSSIONS):** **- site positions** **- monitoring actions** **- sampling frequency**

- **duration**

17:00 **CLOSURE**

19:00 **DINNER**

30 JULY 1997

07:00 **BREAKFAST**

08:00 **[2H]** **CONTINUE WITH PREVIOUS SESSION**

10:00 **[30]** **TEA**

10:30 **[30]** **IDENTIFY (GROUP DISCUSSIONS)**

- **WHAT PROPOSED MONITORING ACTIONS ARE COVERED BY OTHER MONITORING ACTIONS**

11:00 **[60]**

- **WHAT ACTIONS CAN BE UNDERTAKEN BY GOVERNMENT AGENCIES**

12:00 **[60]** **BUDGET (TIME) FOR THE ACTIONS THAT CANNOT BE UNDERTAKEN BY GOVERNMENT (GROUP DISCUSSIONS)**

13:00 **[60]** **LUNCH**

14:00 **[30]** **CONTINUE**

14:30 **[60]** **IDENTIFY LISTS OF SPECIALISTS THAT ARE CAPABLE OF UNDERTAKING THE WORK (GROUP DISCUSSION)**

15:30 **[30]** **THE WAY FORWARD**

16:00 **CLOSURE**

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APPENDIX 3

DFS : CONSERVATION AREAS

Lev 1 : Promote natural river ecosystem health and diversity
Lev 2 : To ensure river diversity as part of landscape diversity - Noss
Lev 3 : Category B : largely natural with few modifications
Lev 4 : For each site

DFS : NON-CONSERVATION AREAS

Lev 1 : Same
Lev 2 : Same + sustainable use by rural people
Lev 3 : Mozambique
Sabie : Category B
Rest : Category C
Lev 4 : For each site

OBJECTIVES : IFR 1 MARITE RIVER

- **Maintain perenniality**
- **Maintain sustainable social uses**
- **Maintain foothill coldwater fish assemblage - diversity and endemics**
- **Maintain range of water quality conditions - esp temp**
- **Maintain natural baseflow conditions during dry season**
- **Maintain present channel form - refuges, habitat diversity, terraces & backwaters**
- **Above would cater for aq inverts**
- **ECOLOGICAL CRITICAL SITE FOR MAINTAINING THE MARITE RIVER**

OBJECTIVES : IFR 2 SABIE RIVER

- **Sustain rural lifestyles**
- **Provide the veg flood buffer**
- **Keep downstream areas free of exotic invasive veg.**
- **Zone be part of the KNP buffer-zone.**

(require removal of activities in rip zone, control and removal of exotic veg, rehab)

OBJECTIVES : IFR 3 & 4, 5 SABIE

- **Ensure flows yielding a changing but balanced mix of major habitat and veg types.**
- **Rip veg and geom: Ensure that the process have resulted in present structure are maintained within a naturally occurring range of change. Manage so that no further directional change takes place favouring sedimentation at the expense of water, rapid and rock habitat.**

OBJECTIVES : IFR 6 MUTLUMUVI

- **Maintain perenniality**
- **Maintain sustainable social uses**
- **Maintain unique comp and diversity of the Lowveld fish assemblage, so that site serves as a refuge for the Sand River**
- **Maintain range of water quality conditions - esp temp**
- **Maintain rip veg dependant on contact with open water**
- **Maintain natural baseflow conditions during dry season**
- **Maintain present diversity of morphological features - reduce the potential for sediment aggradation**

OBJECTIVES : IFR 7 SAND RIVER

- **Maintain perenniality for bedrock sections - non-drought**
- **Maintain bedrock pools as refuge areas**
- **Maintain rip veg dependant on contact - open water**
- **Maintain geomorphological diversity**
- **Maintain hydrological variability**
- **Prevent excessive sedimentation at channel edges and increase in terrestrialisation.**
- **Provide reasonable flows for other fauna.**
- **Ecotourism catered by above.**
- **Assume above cater for quality & invert**

OBJECTIVES : IFR 8 SAND RIVER

- **Near natural**
- **Main sediment source for lower Sabie**
- **Ensure perennial flow with intermittent subsurface flow in places**
- **Variable flow regime with low baseflows and numerous floods to maintain natural sediment dynamics & braided Sabie section**
- **Avoid Letaba**

APPENDIX 4

Drought invertebrate indicators:

Trichoptera	***Chimarra spp***
	Philopotamidae
	Aethaloptera spp
Ephemeroptera	***Cloeon spp***
	Trichorythus spp
	Acentrella spp
	Demoulina spp
Hemiptera	**Pleidae**
Diptera	**Tabamidae**
Mollusca	**Sphaeridae**